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Research Article

Analysis of Management Elements in Antibiotic Inventory Control with EOQ and MMSL Methods at Aisyiyah Bojonegoro Hospital

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Abstract

Inventory control is important in managerial activities because it involves investment and is hospitals' most significant expenditure component. The Aisyiyah Bojonegoro Hospital requires a logistics management system that can maintain the safety and effectiveness of the use of drugs for the smooth running of hospital pharmaceutical services in the long term. This analytical observational study analyzes management elements in controlling antibiotic inventory by simulating the Economic Order Quantity (EOQ) and Minimum-Maximum Stock Level (MMSL) methods. Determination of the sample purposively, i.e., 17 types of antibiotic drugs category A from the results of the ABC analysis, with the inclusion criteria being high cost, high volume, clinically important drugs for antibiotic drugs that are included in the 2020 Hospital Formulary and the exclusion criteria are drugs with inadequate supply. The analysis technique used the Mann-Whitney test and the Kruskal-Wallis test. Based on the results of the study, it was concluded that. Applying the EOQ and MMSL methods has been proven to increase the efficiency and effectiveness of the supply of category A antibiotics at Aisyiyah Bojonegoro Hospital.

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INTRODUCTION

Based on The Law of the Republic of Indonesia Number 44 of 2009 concerning Hospitals, it is stated that the hospital is a health service institution that provides complete individual health services that provide inpatient, outpatient, and emergency services. Meanwhile, pharmaceutical services are an integral part of integral part of the health care system within the hospital. Pharmaceutical services are supporting services and, at the same time, the main revenue center[1]. The purpose of pharmaceutical services is to ensure the availability of good quality, smooth distribution and affordability of drugs, and the availability of types and quantities of drugs to meet public health needs[2].

Drug management in hospitals is a vital management aspect because its inefficiency will negatively impact hospitals medically and economically[3]. Inventory management is the core of the system. The pharmaceutical inventory aims to minimize total inventory costs and optimize quality[4], balance stock out and over stock, and avoid financial losses as the ultimate goal[5]. Procurement is a continuous activity starting from the selection, determination of the required amount, adjustment between needs and funds, selection of procurement methods, supplier selection, determination of contract specifications, monitoring of the procurement process, and payment[6]. Effective procurement must ensure availability, quantity, and time at an affordable price and by quality standards[7].

The percentage of spending on antibiotics from the total spending on pharmaceutical supplies at Aisyiyah Bojonegoro Hospital shows that in 2018 it reached 28.25% with an antibiotic spending value of IDR 6,045,618,320. Meanwhile, in 2019 it reached 20.08% with an antibiotic spending value of IDR 5,043,476,179. Considering that the percentage of antibiotic

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spending at Aisyiyah Bojonegoro Hospital is stable at 20-30% per year, the success of management in controlling the value of spending on antibiotics means being able to control most of the spending value at the Pharmacy Installation. Based on the initial survey at the Aisyiyah Bojonegoro Hospital Pharmacy Installation shows that inventory control management implemented using the consumption method has not been able to control drug supplies optimally. The consumption method can provide good accuracy predictions in planning drug needs but only predicts how many drug needs will be planned without knowing when to order drugs again[8].

The management of the Aisyiyah Bojonegoro Hospital Pharmacy Installation has attempted to create budget efficiency without reducing the quality of health services in the post-Covid-19 pandemic, whose impact is still being felt today. The quality service in question is an integrated and comprehensive service system through appropriate drug planning management to guarantee that individual patients may obtain qualified drugs, increase drug use efficiency, and reduce drug costs for patients[9]. The efficiency of antibiotics supplies drugs can be achieved using Economic Order Quantity (EOQ) inventory method based on ABC (Always, Better, Control) analysis which is expected to reduce inventory value, increase Inventory Turn Over Ratio (ITOR), and increase customer service level[10]. Economic Order Quantity is the amount of inventory that can be ordered in a period to minimize inventory cost[11]. This method can answer questions about conditions that often occur in hospital pharmacy installations: determining the number of pharmaceutical supplies and medicines that are by hospital needs, neither too high nor too low, to reduce losses that occur in hospitals due to management inaccuracy in processing inventory[12].

The decline in the quality of services in hospitals, especially pharmacy installations, can also be caused by the stock of drug supplies[13,14]. To anticipate the tendency of hospitals to carry out excessive procurement patterns, but on the other hand, they can also find out what the minimum stock is so that there is no stock out; it is necessary to calculate the maximum and minimum stock values using the Minimum-Maximum Stock Level (MMSL) method. This method is an inventory control by considering the safety stock so that the reorder point for each item of pharmaceutical supplies can be determined[15,16]. Previous research from Dewi *et al*.[12] analyzed cost-efficiency management of drug supply via EOQ and MMSL in hospitals. It shows that EOQ is the most effective and efficient method to manage the stock of drugs at hospital pharmacies. It causes minimum opportunity loss and opportunity cost and thus is an effective and efficient drug inventory method compared to MMSL and usual consumption methods at RA Basoeni Hospital, Mojokerto.

Analysis of antibiotic drug inventory planning by applying the EOQ and MMSL methods related to inventory control at Aisyiyah Bojonegoro Hospital is needed to avoid high inventory values at the end of the year, anticipate death stock and stockouts, and increase the ITOR value for antibiotic drugs. Therefore, this study aimed to determine the method of planning antibiotics supply by the characteristics of pharmaceutical supplies at Aisyiyah Bojonegoro Hospital using the EOQ and MMSL methods. Then, the control of antibiotic drug inventory that had been simulated was associated with the impact of the application of the two methods on the management element analysis, including the elements of man, material, and method.

MATERIALS AND METHODS

Materials

This study was an analytical observational study to analyze management elements in antibiotic inventory control, and observations were carried out sequentially in time based on secondary retrospective research data from logistics management data for category A antibiotics at the Aisyiyah Bojonegoro Hospital Pharmacy Installation for one period at 2022.

Methods

The research method that the author used was a qualitative analysis method as a form of analysis of the simulation of the implementation of logistics management methods that have been carried out by comparing the value of inventory, ITOR, death stock, and stock out, as well as the aftermath of the impact on management elements. Determination of the sample purposively with antibiotic drugs category A from the results of the ABC analysis, with inclusion criteria being high cost,

high volume, clinically important drugs in antibiotic drugs that were included in the Hospital Formulary in 2020 and the exclusion criteria were drugs with unstable supply.

Data analysis

A comparison test between the new methods (EOQ and MMSL) and the existing method (Consumption method) was carried out to find out whether there were differences in the dependent variable resulting from the independent variables with unpaired non-parametric data with the Mann-Whitney test analysis and a comparison test of more than two groups with Kruskal-Wallis.

RESULTS AND DISCUSSION

Results of analysis with ABC method

Before analyzing the application of consumption methods and simulations, ABC analysis or Pareto analysis was carried out on data on the use of antibiotics to obtain drugs in category A according to the inclusion criteria and stability of drug supply during 2020; therefore, more is needed to just once data collection. Based on data on drug grouping at Aisyiyah Bojonegoro Hospital with ABC analysis, it is known that from 1442 items of drugs and medical devices managed by the Aisyiyah Bojonegoro Hospital Pharmacy Installation, 138 types of antibiotic drugs are included in groups A, B, and C.

The results of ABC analysis based on usage value and investment value are shown in **Table I**, which shows that the study sample consisted of 17 types of antibiotic drug category A (high cost, high volume) with a cumulative value of usage between 0-80% and included in the 2020 National Formulary (clinically important drug), and the supply drugs during January to December 2020 was stable. Stable supply means that there is a similarity between the number of orders and the number of receipts or deliveries from suppliers or distributors[13].

Table I. ABC analysis in determining research samples at Aisyiyah Bojonegoro Hospital in 2020 (Source: Aisyiyah Bojonegoro Hospital Pharmacy Installation Logistics Data, 2020)

No	Types of Antibiotics	Cost (IDR)	Cumulative value (IDR)	Classification
1	Cefxon Inj 1 g	1,643,426,475	1,643,426,475	A
2	Terfacef Inj 1 g/28	921,094,980	2,564,521,455	A
3	Cefila Cap 100 mg/30	758,669,309	3,323,190,764	A
4	Cefim Inj 1 g	568,639,060	3,891,829,824	A
5	Fourcef Inj 1 g	402,322,800	4,294,152,624	A
6	Broadced Inj 1 g	363,448,800	4,657,601,424	A
7	Cefobactam Inj	327,172,230	4,984,773,654	A
8	Cefspan Cap 100 mg/30	266,021,141	5,250,794,795	A
9	Baquinor Inf 100 mL	207,974,268	5,458,769,063	A
10	Cravox Inf 500 mg	203,132,754	5,661,901,817	A
11	Cravox Tab 500 mg/10	161,426,567	5,823,328,384	A
12	Starxon Inj 1 g	144,317,580	5,967,645,964	A
13	Sporetik 100 mg/30	140,049,301	6,107,695,265	A
14	Simextam Inj 1 g	138,560,400	6,246,255,665	A
15	Cefila Ds 30 mL	127,400,402	6,373,656,067	A
16	Pelastin Inj	127,053,432	6,500,709,499	A
17	Sporetik 200 mg/10	126,444,197	6,627,153,696	A

ABC analysis in 2020 showed that category A antibiotics amounted to 17 items (12.32%) of the total antibiotic items in the Pharmacy Installation with an investment value of IDR 6,627,153,696 (86.90%) of the total investment value of antibiotics or 20.5% of the total value of pharmaceutical inventory in the Aisyiyah Bojonegoro Hospital Pharmacy Installation. Category B antibiotics were 48 items (34.78%) of the total antibiotic items with an investment value of IDR 876,478,766 (11.49%) of the total antibiotic investment value or 2.7% of the total value of pharmaceutical inventory in the Aisyiyah Bojonegoro Hospital Pharmacy Installation. At the same time, category C antibiotics were 73 items (52.90%) of the total antibiotic items with an investment value of IDR 122,951,269 (1.61%) of the total investment value of antibiotics or 0.38% of the total value of pharmaceutical inventory in the Aisyiyah Bojonegoro Hospital Pharmacy Installation. The results of the ABC analysis based on the investment value of antibiotics are presented in detail in **Table II**. Thus, category A antibiotic drugs occupied the most significant investment value in Aisyiyah Bojonegoro Hospital Pharmacy Installation, with 86.90% of the total

investment value for antibiotics or 20.5% of the total investment in pharmaceutical supplies at the Aisyiyah Bojonegoro Hospital Pharmacy Installation. This becomes a reason that category A antibiotics need to be a priority for inventory control.

Table II. Classification of antibiotic drugs with ABC analysis based on investment value at Aisyiyah Bojonegoro Hospital in 2020 (Source: Aisyiyah Bojonegoro Hospital Pharmacy Installation Logistics Data, 2020)

Categories	Items	% Items	Investment value (IDR)	% Investment cumulative
A	17	12.32	6,627,153,696	86.90
B	48	34.78	876,478,766	11.49
C	73	52.90	122,951,269	1.61
Total	**138**	**100**	**7,626,583,731**	**100**

Recording of category A antibiotic procurement calculation based on consumption method

Table III shows data on inventory value, ITOR, death stock, and stockout of category A antibiotics from January to December 2020 based on the consumption method. **Table I** shows that the highest price of category A antibiotic drug is Pelastin Inj of IDR 433,727 per vial, and the lowest price for category A antibiotic is Sporetik 100 mg of IDR 25,450. The inventory cost of category A antibiotics is calculated by multiplying the purchase price of antibiotics by the amount used. The highest inventory cost was Cefim Inj 1 g, with a value of IDR 1,242,019,334, and the lowest inventory cost was Cefspan Cap 100 mg, with a value of IDR 33,134,640. The most significant number of early inventories was Cefila Cap 100 mg amounting to 916, and the smallest number was Starxon Inj 1 g amounting to 12. Meanwhile, the most significant number of the ending inventory was Cefila Cap 100 mg totaling 485; the smallest number of the ending inventory, empty or depleted, was Broadced Inj 1 g. Inventory value, ITOR, and death stock are efficiency indicators, while stockout values are effectiveness indicators. The following is the calculation of this study's efficiency and effectiveness indicators[17].

1. Inventory Value
   Inventory value is obtained from the calculation of the final stock of the drug multiplied by the price of each drug item[18]. The most considerable inventory value for the consumption method was Cefim Inj 1 g of IDR 55,205,454, while the smallest inventory value for the consumption method was Cefspan Cap 100 mg/30 of IDR 145,200.
2. Inventory Turn Over Ratio
   Inventory Turn Over Ratio is one of the benchmarks in the efficiency of antibiotic inventory control. Inventory Turn Over Ratio shows the inventory turnover ratio between sales and purchases of a particular antibiotic inventory. Inventory Turn Over Ratio comparison of each method is based on calculating the cost of good sold divided by the average inventory value[10]. Inventory Turn Over Ratio data in **Table III** shows the highest ITOR value for the consumption method is Cefim Inj 1 g (36.19), while the lowest ITOR value is Cefspan Cap 100 mg/30 (3.23).
3. Death Stock
   Death stock is the stock of antibiotic drugs at the Pharmacy Installation that does not move for three months or more, resulting in stockpiling of drugs, even expiry[19]. The calculation of the death stock of category A antibiotics in the Aisyiyah Bojonegoro Hospital Pharmacy Installation for 2020 using the consumption method is shown in **Table III**. There are six types of category A antibiotics recorded as death stock in the application of the consumption method (the existing method), including 1 g Broadced Inj, Cefobactam Inj, Cefspan Cap 100 mg, Baquinor Inf 100 mL, Cravox Inf 500 mg, and Simextam Inj 1 g, while the other 11 category A antibiotics did not experience death stock. The highest death stock value was Cefspan Cap 100 mg/30, 210 items or IDR 6,098,400. The lowest death stock value was Baquinor Inf 100 mL for 10 items or IDR 3,000,250.
4. Stock Out
   Measurement of effectiveness indicators uses stockout value data. Stockout is a condition where the amount of stock of antibiotic drugs in the Pharmacy Installation is empty, or the stock is 0 (zero) when there is a demand for that type of drug so that it fails to be served. Stockout occurs if, in inventory management, there is a final stock of drugs that is less than the average amount of use each month so that when there is a demand for the drugs, the stock is empty. Stockout conditions can cause losses for the patients, material losses for hospitals, and affect the quality of hospital services[20].

Table III shows that there are seven antibiotics category A that experienced stockout during the application of the consumption method, including Cefxon Inj 1 g, Cefila Cap 100 mg, Fourcef Inj 1 g, Broadced Inj 1 g, Cefspan Cap 100 mg, Cravox Inf 500 mg, and Pelastin Inj. Thus, 10 other category A antibiotics did not experience stockout. The most immense

stockout value was antibiotic Cefspan Cap 100 mg/30, as many as 691 caps (IDR 20,066.640), while the smallest stockout value was antibiotic Pelastin Inj, as many as 25 vials (IDR 10,843,175).

Table III. Data on inventory value, ITOR, death stock and stockout of category A antibiotics using Consumption method at Aisyiyah Bojonegoro Hospital in 2020 (Source: Aisyiyah Bojonegoro Hospital Pharmacy Installation Logistics Data, 2020)

No.	Drug names	Price (Rp)	Total use	IC (Rp)	Early invent	Ending invent	Inventory value	ITOR	Death stock		Stock out	
									Item	Rp	Item	Rp
1.	Cefxon Inj 1 g	277,200	3,092	857,102,400	153	91	25,225,200	25.34	0	0	45	12,474,000
2.	Terfacef Inj 1 g/ 28	271,656	1,318	358,042,608	76	55	14,941,080	20.12	0	0	0	0
3.	Cefila Cap 100 mg/30	25,740	13,234	340,643,160	916	485	12,483,900	18.89	0	0	394	10,141,560
4.	Cefim Inj 1 g	206,762	6,007	1,242,019,334	65	267	55,205,454	36.19	0	0	0	0
5.	Fourcef Inj 1 g	382,800	529	202,501,200	75	24	9,187,200	10.69	0	0	39	14,929,200
6.	Broadced Inj 1 g	257,400	223	57,400,200	28	0	0	15.93	37	9,523,800	53	13,642,200
7.	Cefobactam Inj	260,297	583	151,753,151	72	73	19,001,681	8.04	115	29,934,155	0	0
8.	Cefspan Cap 100 mg/30	29,040	1,141	33,134,640	701	5	145,200	3.23	210	6,098,400	691	20,066,640
9.	Baquinor Inf 100 mL	300,025	251	75,306,275	46	27	8,100,675	6.88	10	3,000,250	0	0
10.	Cravox Inf 500 mg	345,284	395	136,387,180	23	15	5,179,260	20.79	28	9,667,952	27	9,322,668
11.	Cravox Tab 500 mg/10	48,555	2,882	139,935,510	144	262	12,721,410	14.20	0	0	0	0
12.	Starxon Inj 1 g	296,340	454	134.538.360	12	51	15.113.340	14.41	0	0	0	0
13.	Sporetik 100 mg/30	25,450	3,151	80,192,950	323	257	6,540,650	10.87	0	0	0	0
14.	Simextam Inj 1 g	231,199	210	48,551,790	33	54	12,484,746	4.83	30	6,935,970	0	0
15.	Cefila Ds 30 mL	109,560	691	75,705,960	48	21	2,300,760	20.03	0	0	0	0
16.	Pelastin Inj	433,727	306	132,720,462	66	24	10,409,448	6.80	0	0	25	10,843,175
17.	Sporetik 200 mg/10	36,861	2,871	105,827,931	141	175	6,450,675	18.17	0	0	0	0

Note: ITOR: Inventory Turn Over Ratio; IC: Inventory Cost

Recording of category A antibiotic procurement calculation based on EOQ method

Table IV contains data for category A antibiotics from January to December 2020 based on the simulation of the EOQ method. The inventory cost for category A antibiotics is calculated by multiplying the purchase price of antibiotics by the amount used, similar to that in planning with the consumption method. The data showed that the most extensive ending inventory was Sporetik 200 mg totaling 196 caps, and the smallest ending inventory was Cefxon Inj and Pelastin Inj, each with three vials. Meanwhile, two antibiotics had an ending inventory value of zero, the Broadced Inj and Cefobactam Inj. The average ending inventory for category A antibiotics with the EOQ method was 44 units or lower than that for the consumption method, 110 units. The following is the calculation of the efficiency and effectiveness indicators used in this study for the EOQ method.

1. Inventory Value
   Inventory value is an indicator in assessing the efficiency of antibiotic inventory control using the EOQ method. **Table IV** shows that the largest inventory value for the EOQ method is Cefim Inj 1 g of IDR 25,638,488, while the smallest inventory value for the EOQ method is Cefspan Cap 100 mg of IDR 580,800. In addition, two antibiotics in category A have a zero-inventory value because the stock for the final inventory is also zero: Broadced Inj 1 g and Cefobactam Inj.
2. Inventory Turn Over Ratio
   Inventory Turn Over Ratio is used to measure the efficiency of antibiotic inventory control. **Table IV** shows that the highest ITOR value for the EOQ method is Cefim Inj 1 g (63.57), while the lowest ITOR value is Cefspan Cap 100 mg/30 (3.17).

3. Death Stock

   Similar to inventory value and ITOR, death stock is also used to measure the efficiency of inventory control for category A antibiotics in this study. **Table IV** shows that two antibiotics in category A experienced death stock in the simulation of applying the EOQ method: Cravox Tab 500 mg and Sporetik 200 mg, while 15 other category A antibiotics did not experience death stock. The lowest death stock value was Cravox Tab 500 mg with 1 item (IDR 48,555), while the highest death stock was Sporetik 200 mg with 63 items (IDR 2,322,243).

4. Stockout

   The stockout value is used to measure the effectiveness indicator of the EOQ method[21]. **Table IV** shows that no category A antibiotics experienced stockout during the implementation of the EOQ simulation method.

Table IV. Data on inventory value, ITOR, death stock and stockout of category A antibiotics using a simulation of EOQ method at Aisyiyah Bojonegoro Hospital in 2020 (Source: Aisyiyah Bojonegoro Hospital Pharmacy Installation Logistics Data, 2020)

No.	Drug names	Price (Rp)	Total use	IC (Rp)	Early invent	Ending invent	Inventory value	ITOR	Death stock		Stock out	
									Item	Rp	Item	Rp
1.	Cefxon Inj 1 g	277,200	3,092	857,102,400	153	3	831,600	39.64	0	0	0	0
2.	Terfacef Inj 1 g/ 28	271,656	1,318	358,042,608	76	9	2,444,904	31.01	0	0	0	0
3.	Cefila Cap 100 mg/30	25,740	13,234	340,643,160	916	114	2,934,360	25.70	0	0	0	0
4.	Cefim Inj 1 g	206,762	6,007	1,242,019,334	65	124	25,638,488	63.57	0	0	0	0
5.	Fourcef Inj 1 g	382,800	529	202,501,200	75	8	3,062,400	12.75	0	0	0	0
6.	Broadced Inj 1 g	257,400	223	57,400,200	28	0	0	15.93	0	0	0	0
7.	Cefobactam Inj	260,297	583	151,753,151	72	0	0	16.19	0	0	0	0
8.	Cefspan Cap 100 mg/30	29,040	1,141	33,134,640	701	20	580,800	3.17	0	0	0	0
9.	Baquinor Inf 100 mL	300,025	251	75,306,275	46	9	2,700,225	9.13	0	0	0	0
10.	Cravox Inf 500 mg	345,284	395	136,387,180	23	9	3,107,556	24.69	0	0	0	0
11.	Cravox Tab 500 mg/10	48,555	2,882	139,935,510	144	140	6,797,700	20.30	1	48,555	0	0
12.	Starxon Inj 1 g	296,340	454	134,538,360	12	27	8,001,180	23.28	0	0	0	0
13.	Sporetik 100 mg/30	25,450	3,151	80,192,950	323	31	788,950	17.80	0	0	0	0
14.	Simextam Inj 1 g	231,199	210	48,551,790	33	31	7,167,169	6.56	0	0	0	0
15.	Cefila Ds 30 mL	109,560	691	75,705,960	48	19	2,081,640	20.63	0	0	0	0
16.	Pelastin Inj	433,727	306	132,720,462	66	3	1,301,181	8.87	0	0	0	0
17.	Sporetik 200 mg/10	36,861	2,871	105,827,931	141	196	7,224,756	17.04	63	2,322,243	0	0

Note: ITOR: Inventory Turn Over Ratio; IC: Inventory Cost

Recording of category A antibiotic procurement calculation based on MMSL method

Table V shows that the inventory management of category A antibiotics using the MMSL method simulation showed that the drug with the most considerable ending inventory value was Cefim Inj 1 g totaling 15 vials. Those with the smallest ending inventory were Fourcef Inj, Broadced Inj, Cefobactam Inj, Cefspan Cap 100 mg, Baquinor Inf 100 mL, Simextam Inj, Pelastin Inj, and Sporetik 200 mg each with ending supply of zero unit or empty. Thus, the average ending inventory for category A antibiotics using the MMSL method was two units. This means that the average supply of category A antibiotics using the MMSL method was smaller than the consumption method (110 units) and the EOQ method (44 units). The following is the calculation of the efficiency and effectiveness indicators used in this study for the MMSL method.

1. Inventory Value

   Inventory value is an indicator in assessing the efficiency of antibiotic inventory control using the MMSL method[22]. **Table V** shows that the drug with the largest inventory value for the MMSL method was Cefim Inj 1 g of IDR 3,101,430, while the drug with the smallest inventory value for the MMSL method was Sporetik 100 mg of IDR 76,350. In addition, eight types of category A antibiotics had zero inventory value because the stock for the final inventory was also zero, i.e.,

Fourcef Inj 1 g, Broadced Inj 1 g, Cefobactam Inj, Cefspan Cap 100 mg, Baquinor Inf 100 mL, Simextam Inj, Pelastin Inj, and Sporetik 200 mg.

2. Inventory Turn Over Ratio

   Inventory Turn Over Ratio is used to measure the efficiency of antibiotic inventory control. **Table V** shows drug with the highest ITOR value for the MMSL method is Cefim Inj 1 gr, which is 150.18, and the lowest ITOR value is Cefspan Cap 100 mg, which is 3.26.

3. Death Stock

   Death stock value is used to measure the efficiency of inventory control for category A antibiotics in the MMSL method. **Table V** shows one type of antibiotic category A that experienced death stock in applying the MMSL method: Cefila Ds 30 mL as many as 97 items (IDR 10,627,320), while 16 other category A antibiotics did not experience death stock.

4. Stockout

   The stockout value is used to measure the effectiveness indicator for the MMSL method. **Table V** shows that there were no category A antibiotics that experienced stockout during the application of the MMSL method.

Table V. Data on inventory value, ITOR, death stock and stockout of category A antibiotics using a simulation of MMSL method at Aisyiyah Bojonegoro Hospital in 2020 (Source: Aisyiyah Bojonegoro Hospital Pharmacy Installation Logistics Data, 2020)

No.	Drug names	Price (Rp)	Total use	IC (Rp)	Early invent	Ending invent	Inventory value	ITOR	Death stock		Stock out	
									Item	Rp	Item	Rp
1.	Cefxon Inj 1 g	277,200	3,092	857,102,400	153	4	1,108,800	39.39	0	0	0	0
2.	Terfacef Inj 1 g/ 28	271,656	1,318	358,042,608	76	1	271,656	34.23	0	0	0	0
3.	Cefila Cap 100 mg/30	25,740	13,234	340,643,160	916	9	231,660	28.61	0	0	0	0
4.	Cefim Inj 1 g	206,762	6,007	1,242,019,334	65	15	3,101,430	150.18	0	0	0	0
5.	Fourcef Inj 1 g	382,800	529	202,501,200	75	0	0	14.11	0	0	0	0
6.	Broadced Inj 1 g	257,400	223	57,400,200	28	0	0	15.93	0	0	0	0
7.	Cefobactam Inj	260,297	583	151,753,151	72	0	0	16.19	0	0	0	0
8.	Cefspan Cap 100 mg/30	29,040	1,141	33,134,640	701	0	0	3.26	0	0	0	0
9.	Baquinor Inf 100 mL	300,025	251	75,306,275	46	0	0	10.91	0	0	0	0
10.	Cravox Inf 500 mg	345,284	395	136,387,180	23	1	345,284	32.92	0	0	0	0
11.	Cravox Tab 500 mg/10	48,555	2,882	139,935,510	144	4	194,220	38.95	0	0	0	0
12.	Starxon Inj 1 g	296,340	454	134,538,360	12	4	1,185,360	56.75	0	0	0	0
13.	Sporetik 100 mg/30	25,450	3,151	80,192,950	323	3	76,350	19.33	0	0	0	0
14.	Simextam Inj 1 g	231,199	210	48,551,790	33	0	0	12.73	0	0	0	0
15.	Cefila Ds 30 mL	109,560	691	75,705,960	48	1	109,560	28.20	97	10,627,320	0	0
16.	Pelastin Inj	433,727	306	132,720,462	66	0	0	9.27	0	0	0	0
17.	Sporetik 200 mg/10	36,861	2,871	105,827,931	141	0	0	40.72	0	0	0	0

Note: ITOR: Inventory Turn Over Ratio; IC: Inventory Cost

Supporting factors and inhibiting factors for the application of EOQ and MMSL methods in antibiotic inventory control

Focus group discussion conducted by the informants of this study, consisting of the parties directly involved in drug management, showed that the management of category A antibiotic drugs, as currently carried out using the consumption method, has proven to produce high inventory values and low ITOR, so it was not economically profitable for Aisyiyah Bojonegoro Hospital. The trials of the EOQ and MMSL methods with ABC analysis of category A antibiotics at the Pharmacy Installation of Aisyiyah Bojonegoro Hospital had been proven to reduce the inventory values and increase the ITOR. The research informants in this study consisted of the Head of Pharmacy Installation, Pharmacy Logistics Supervisor, Head of Finance, Pharmacy and Therapy Committee, Deputy Director of Administration and Finance, Pharmacy Staff, and Ward Nurses. The results of the FGD process by the informants are presented in **Table VI**.

Table VI. Qualitative comparison of consumption, EOQ, and MMSL methods (Source: Focus Group Discussion Aisyiyah Bojonegoro Hospital, 2021)

Method	Supporting factors	Impending factors
EOQ	a. Determination of when to order based on reorder point (ROP) to minimize stockout. b. Determination of the number of orders based on Quantity Order (Qo) to minimize excess inventory. c. Proven to have a significant impact in reducing inventory value compared to consumption method. d. Proven to prevent stockout. e. Budgeting for drug needs can be predicted on an annual scale. f. Able to calculate holding costs and ordering costs.	a. It is difficult for operators because they have to research which items of the drugs reaching the ROP point. b. Difficulty calculating storage costs accurately, given the volume of each drug and the need for different storage resources (e.g. electricity) for each drug. c. Changing the habits of pharmaceutical logistics staff from the consumption method pattern to the EOQ method. d. Highly dependent on information technology system for ROP scrutiny to minimize stockouts.
MMSL	a. Determining when to order based on Minimum Stock (Smin) to minimize stockout. b. Determination of the number of orders based on 7-day service requirements or maximum stock (Smax) to minimize excess inventory. c. Proven to have a significant impact in reducing inventory value compared to consumption method. d. Proven to have a significant impact in increasing the ITOR compared to consumption method. e. Proven to have a significant impact on the decrease in the value of death stock compared to consumption method. f. Proven to prevent stockout. g. Very sensitive to fluctuations in the number of patients and the need for drug prescription.	a. Makes it difficult for the operators because they have to examine any drug items that are less or equal to the minimum stock (Smin). b. The drug order process is carried out weekly, it can even be more than once per week according to fluctuations in real drug needs in the service. c. Budgeting for the cost of drug needs cannot be predicted on an annual basis, because it follows the fluctuating demand for real services. d. Changing the habits of pharmacy logistics staff from the pattern of consumption method to MMSL method. e. Highly dependent on IT systems for Minimum Stock (Smin) scrutiny to minimize stockout.

Analysis of management elements as the impact of EOQ and MMSL method application

Every choice made always has an impact or risk that must be anticipated. **Table VII** shows the impact analysis if the EOQ or MMSL method is applied at Aisyiyah Bojonegoro Hospital. The results of the added value analysis, if the EOQ method is applied at Aisyiyah Bojonegoro Hospital, are shown in **Table VIII**.

Table VII. Analysis of management elements as the impact of EOQ method application at Aisyiyah Bojonegoro Hospital

No	Parameters	Pre/consumption method (IDR)	Post/EOQ method (IDR)	Difference (IDR)
A.	**Human resources**			
1	Logistic Coordinator Allowance (Pharmacist)	-	2,200,000 x 12 months = 26,400,000	26,400,000
B.	**Materials**			
1	IT Team Empowerment	-	3 persons x 7 days x 105,000 per hour = 2,205,000	2,205,000
2	Consultation to IT Consultant	-	3 x 1,500,000 = 4,500,000	4,500,000
3	Program finishing	-	5,500,000	5,500,000
C.	**Methods**			
1	Socialization and technical assistance	-	Participation in annual routine education for inhouse training	-
2	Ordering cost	32,500 x 24 times/years x 17 antibiotic items = 13,260,000	32,500 x 48 times/years x 17 antibiotic items = 26,520,000	13,260,000
	Total			**51,865,000**

Table VIII. Analysis of the added value from the EOQ method application at Aisyiyah Bojonegoro Hospital

No	Parameters	Pre/Consumption method (IDR)	Post/EOQ method (IDR)	Difference (IDR)
1	Inventory cost	215,490,674	74,662,912	140,827,762
2	Death stock	65,160,527	2,370,798	62,789,729
3	Stock out	91,419,443	0	91,419,443
	Total			**295,036,934**

There has been a change in the number of human resources (man), infrastructure (material), system (method), and financing (money). The application of the EOQ method had an impact in the form of increasing the workload of the procurement department because the frequency of procurement increased, so it will be necessary to increase the level of the head of logistics, not equivalent to a supervisor but to become a coordinator led by a pharmacist who has the authority to make

more strategic decisions, one of which is ordering drugs[23]. The pharmaceutical logistics leadership position will also be equivalent to the coordinator with an allowance of IDR 2,200,000 per month, increased from the supervisor-level allowance in the previous system of IDR 500,000 per month. So, IDR 1,700,000 per month or IDR 20,400,000 per year will be added.

Changes also occurred in the facilities and infrastructure needed, such as improving the information system program (software). It will be necessary to empower the IT team with extra working hours considering that this is not a routine activity in the IT team, with overtime of IDR 15,000 per hour for seven hours per day for seven days with three IT staff so that the total overtime financing will be IDR 2,205,000. The overtime value of IDR 15,000 per hour was based on the Regency Minimum Wage of IDR 2,400,000 per month divided by 40 working hours per week, then divided by 4 (a month consists of four weeks). The cost of consulting an IT Consultant needs to be done three times periodically for IDR 1,500,000 with a total of IDR 4,500,000. They were finishing a program of IDR 5,500,000. This information system upgrade will be only done once, then what is needed will be software and hardware maintenance supported by routine maintenance costs budgeted for by the hospital so that it will not require separate financing.

The system is also changing with new procedures and requires socialization and training of related staff. However, the financing for this process has been budgeted for in the annual routine exhouse training in education and training programs, so there will be no need for special financing[24]. In the EOQ method, based on the average simulation, the procurement process was carried out once a week or 48 times a year. This changed the average habit of the existing method that the procurement process was carried out twice a month or 24 times a year. This means that there will be an increase of two times more often than before. The cost of each order was IDR 32,500 if the existing method was carried out 24 times a year with 17 items of antibiotics, so it would require an annual ordering fee of IDR 13,260,000 per year. In the EOQ method, the number of orders 48 times a year with 17 items of antibiotics required a cost of = IDR 26,520,000 per year. There will be a more expensive difference in ordering financing of IDR 13,260,000 annually.

From the man, material, and method analysis, the total additional cost obtained was IDR 45,865,000 per year. However, the positive impact of the application of the EOQ method was a decrease in the value of inventories from the previous method of IDR 215,490,674 to IDR 74,662,912 so that the difference in efficiency was IDR 140,827,762. The decline in the value of the death stock also showed a decrease from the previous IDR 65,160,527 (existing method) to IDR 2,370,798 (EOQ method), so the difference in efficiency was IDR 62,789,729. The stockout value also differed between the existing methods of IDR 91,419,443 to IDR 0 in the EOQ method, with the addition of an efficiency value of IDR 91,419,443. The total efficiency of applying this EOQ method will be IDR 295,036,934 per year. If this value is deducted from the costs that must be met in applying the EOQ method, an added value of IDR 249,171,934 per year will be added. The results of comparing pre- and post-unit costs for applying the MMSL method are presented in **Table IX**, while added value analysis of the MMSL method is listed in **Table X**.

There has been a change in the number of human resources (man), infrastructure (material), system (method), and financing (money). The application of the MMSL method increased the workload so that it required additional new human resources as staff in pharmaceutical logistics. In addition, an increase in the position level will also be needed[25]. The head of logistics will be different from a supervisor but become a coordinator led by a pharmacist with the authority to make more strategic decisions, one of which is ordering drugs. With this illustration, the financial impact of adding one staff with the competence of a diploma in pharmacy will be the allocation of a total salary per month of IDR 2,430,000 per month or IDR 29,160,000 per year. The pharmaceutical logistics leadership position will also be equivalent to a coordinator with an allowance of IDR 2,200,000 per month, an increase from the supervisor-level allowance in the previous system of IDR 500,000 per month, so there will be an additional IDR 1,700,000 per month or IDR 20,400,000 per year.

Changes also occurred in the facilities and infrastructure needed, such as improvement of the information system program (software), so extra or overtime IT team empowerment will be needed considering this is not a routine IT team activity, with overtime wages of IDR 15,000 per hour for seven hours per day for seven days with three IT staff so that the total overtime financing will be IDR 2,205,000. The overtime value of IDR 15,000 per hour was based on the Regency Minimum Wage of IDR 2,400,000 per month, divided by 40 working hours per week, then divided by 4 (a month consists of four weeks). Consultation with an IT consultant will need to be done three times periodically with a fee of IDR 1,500,000 with a total of IDR 4,500,000 and a finishing program of IDR 5,500,000. This information system upgrade will only be done once, so after that, what is needed will be software and hardware maintenance which would be financed from routine maintenance costs budgeted for by the hospital so that it will not require separate financing.

Table IX. Analysis of impact of MMSL method application at Aisyiyah Bojonegoro Hospital

No	Parameters	Pre/consumption method (IDR)	Post/EOQ method (IDR)	Difference (IDR)
D.	**Human resources**			
1	Addition of 1 logistic staff	-	2,430,000 x 12 months = 29,160,000	29,160,000
2	Logistic Coordinator Allowance (Pharmacist)	-	2,200,000 x 12 months = 26,400,000	26,400,000
E.	**Materials**			
1	IT Team Empowerment	-	3 persons x 7 days x 105,000 per hour = 2,205,000	2,205,000
2	Consultation to IT Consultant	-	3 x 1,500,000 = 4,500,000	4,500,000
3	Program finishing	-	5,500,000	5,500,000
F.	**Methods**			
1	Socialization and technical assistance	-	Participation in annual routine education for inhouse training	-
2	Ordering cost	32,500 x 24 times/years x 17 antibiotic items = 13,260,000	32,500 x 96 times/years x 17 antibiotic items = 53,040,000	39,780,000
	Total			**107,545,000**

Table X. Analysis of the added value from the MMSL method application at Aisyiyah Bojonegoro Hospital

No	Parameters	Pre/Consumption method (IDR)	Post/EOQ method (IDR)	Difference (IDR)
1	Inventory cost	215,490,674	6,624,322	208,866,352
2	Death stock	65,160,527	10,627,320	54,533,207
3	Stock out	91,419,443	0	91,419,443
	Total			**354,819,002**

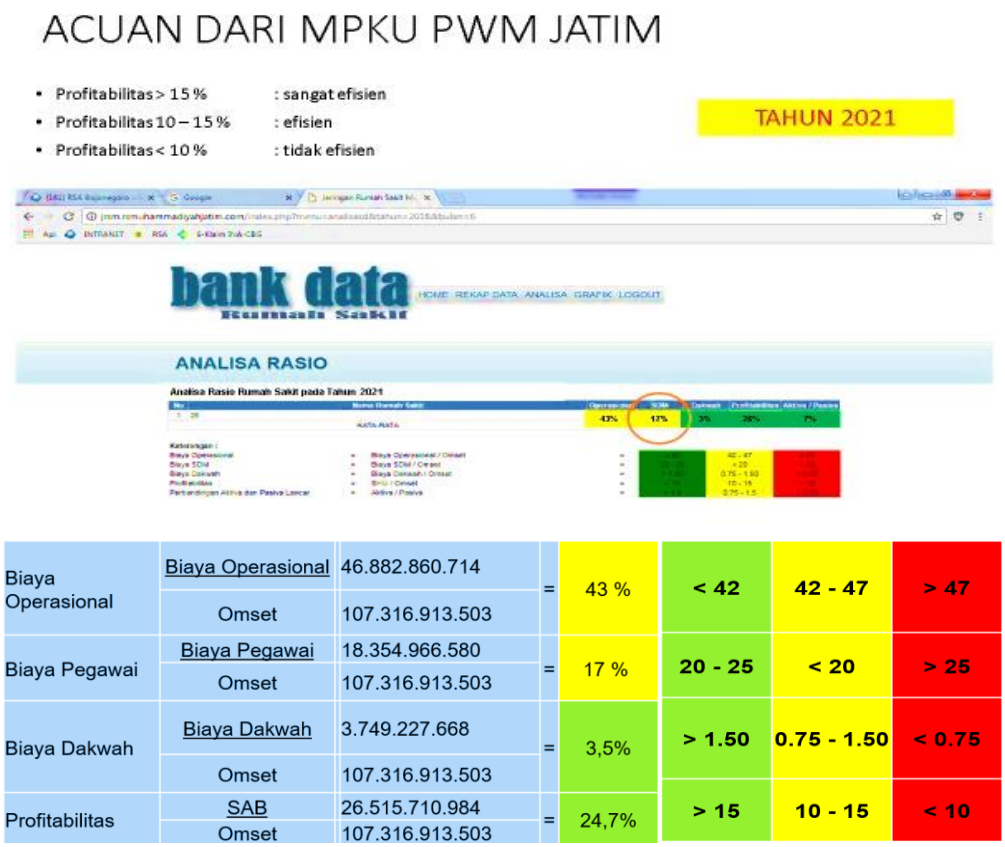
The system was also changing with new procedures that required socialization and training of related staff. However, the financing for this process has been budgeted for in the annual routine exhouse training in education and training programs, so there will be no need for special financing. The MMSL method was based on a simulation that conducted the procurement process on average twice a week or 96 times a year. This changed the average habit of the existing method that carried out the procurement process an average of two times a month or 24 times a year. This means that there will be an increase of four times more often than before. The cost of each order will be IDR 32,500 if the existing method is carried out 24 times a year with 17 items of antibiotics, so that it will require an annual ordering fee of IDR 13,260,000. In the MMSL method, the number of orders was 96 times a year with 17 items of antibiotics, so that it will require a cost of IDR 53,040,000 per year. There will be a more expensive difference in ordering financing of IDR 39,780,000 annually.

Analysis of the man, material, and method approach showed the total additional cost of IDR 101,545,000 per year. However, the positive impact of the MMSL method application was a decrease in inventory value from the previous method of IDR 215,490,674 to IDR 6,624,322, so the difference in efficiency was IDR 208,866,352. The death stock value decreased from the previous IDR 65,160,527 (existing method) to IDR 10,627,320 (MMSL method) with an efficiency difference of IDR 54,533,207. The stockout value was also different from the existing method of IDR 91,419,443 to IDR 0 on the MMSL method, with the addition of the efficiency value of IDR 91,419,443. The total efficiency offered in the MMSL method application was IDR 354,818,802 per year. If this value is deducted from the costs that must be met in the MMSL method application, an added value of IDR 253,273,802 per year will be obtained. In addition, the MMSL method application can prevent drug stockouts and increase service effectiveness and quality.

Tables VIII and **X** show the results of added value analysis of the EOQ and MMSL method application at Aisyiyah Bojonegoro Hospital. The MMSL method is good at decreasing inventory cost than EOQ. The EOQ is better than MMSL in decreasing death stock. Overall, the MMSL method has better different efficiency than EOQ. This finding supported the previous research that EOQ is best in controlling death stock[12]. Optimal ordering planning is obtained based on the proper calculation of the EOQ[26]. The EOQ is best in decreasing death stock. It was observed that the reason for this was the use of ROP (Re-Order Point) that set the minimum limit for reordering in the EOQ method. In the MMSL method, each drug item was determined by its maximum and minimum stock levels, in which when the drug's volume had reached the minimum amount, it would be purchased immediately until the volume reached the optimal stock. This method is appropriate for drugs that are used commonly; as the actively used drug's volume reaches the set minimum level, new purchases will be activated[12].

The analysis also shows the advantages of the EOQ method, in which no additional staff is required, and the frequency of orders is less than the MMSL method[27]. Meanwhile, MMSL requires adding new human resources in the pharmaceutical

logistics department, and the frequency of procurement will be more frequent[28]. However, the added value of efficiency obtained is still superior to the MMSL method. Nevertheless, the priority is referred to the performance assessment of Aisyiyah Bojonegoro Hospital as determined by General Health Supervisory Council (*Majelis Pembina Kesehatan Umum*, MPKU), Muhammadiyah Regional Leadership (*Pimpinan Wilayah Muhammadiyah*, PWM) East Java, Indonesia, as shown in **Figure 1**. According to **Figure 1**, the operational cost ratio score compared to the turnover of Aisyiyah Bojonegoro Hospital is still yellow (sufficient). Better efficiency is needed to go to the color green (good). By comparing the standard of employee or HR costs with turnover, Aisyiyah Bojonegoro Hospital is in yellow (sufficient), which means that adding HR costs by new personnel in pharmaceutical logistics is not a burden but improves the hospital's performance assessment. Thus, the MMSL method, which offers better inventory value efficiency and ITOR by increasing the number of new human resources, is currently the best choice at Aisyiyah Bojonegoro Hospital.



Biaya Operasional	Biaya Operasional	46.882.860.714	=	43 %	< 42	42 - 47	> 47
	Omset	107.316.913.503					
Biaya Pegawai	Biaya Pegawai	18.354.966.580	=	17 %	20 - 25	< 20	> 25
	Omset	107.316.913.503					
Biaya Dakwah	Biaya Dakwah	3.749.227.668	=	3,5%	> 1.50	0.75 - 1.50	< 0.75
	Omset	107.316.913.503					
Profitabilitas	SAB	26.515.710.984	=	24,7%	> 15	10 - 15	< 10
	Omset	107.316.913.503					

Figure 1. Dashboard of performance appraisal reference for Aisyiyah Bojonegoro Hospital (Source: MPKU PWM East Java Website in 2021).

CONCLUSION

As a method of planning and procuring category A antibiotics currently being implemented at the Pharmacy Installation of Aisyiyah Hospital Bojonegoro, the consumption method has resulted in high inventory values, lower ITOR values compared to the new simulated method, and higher death stock and stockout rate. The application of EOQ and MMSL methods has been proven to increase the efficiency of category A antibiotics supply at Aisyiyah Hospital Bojonegoro with the indicators as follows: the decrease in inventory value, the increase in ITOR, and the decrease in the death stock rate. In addition, the application of the EOQ and MMSL methods was also proven to increase the effectiveness of category A antibiotic drug supplies at Aisyiyah Hospital Bojonegoro with an indicator of the decrease in stockout incidence rate. This study showed that applying the MMSL method had a greater chance of reducing the stockout rate than the EOQ and the existing consumption methods. The limitation of this research is that there are several other factors, such as the study location and time.

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AUTHORS' CONTRIBUTION

All authors contributed equally to the research and writing of this article.

DATA AVAILABILITY

None.

CONFLICT OF INTEREST

The author declares that there is no potential conflict of interest in relation to the authorship and publication of this article.

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